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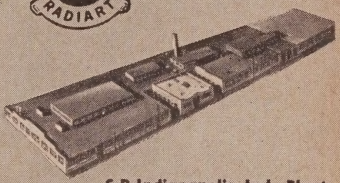

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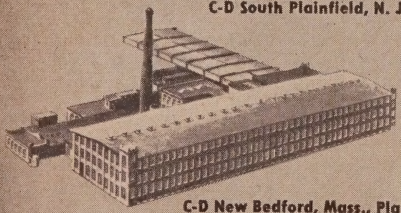

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FREQUENCY AND PHASE MEASUREMENTS WITH THE OSCILLOSCOPE

The need to measure frequencies and phase differences often arises in electronic work. In either instance, the signal components to be compared may be two voltages, two currents, or a current and a voltage. The oscilloscope is extremely useful for these measurements.

This article explains the practical technique of frequency and phase measurement using the oscilloscope as an indicating device. A good working knowledge of this application will pay off in time saved, greater confidence, and increased accuracy.

Underlying Principles

Every 2-dimensional pattern on the scope screen results from the tracing movement of the spot under the simultaneous influence of both vertical and horizontal deflection signals. The position of the spot at any instant is governed by the instantaneous magnitudes of the vertical and horizontal voltages.

In most applications of the scope, a linear sawtooth sweep voltage is applied to the horizontal plates and the test-signal voltage to the vertical. The spot thus moves horizontally with respect to time, and vertically according to the fluctuations in test-signal amplitude. The pattern which it traces displays the signal phenomenon along a linear time base.

Quite a different type of pattern results from application of signal voltages to both sets of plates. Here, the pattern shape is governed by the comparative frequencies of the two signals and their phase relations as well. A good example is the application of sine-wave voltages to both vertical and horizontal.

Consider two equal sine-wave voltages of the same frequency applied to the plates. The horizontal sweep will be sinusoidal at the same rate as that of the vertical signal voltage. At any instant, the voltage attempting to move the spot vertically is equal to the voltage attempting to deflect it horizontally. The instantaneous position of the spot therefore is the resultant of the vertical and horizontal deflection components. This is illustrated in Figure 1.

Figure 1(A) shows the vertical signal wave with several instantaneous positive and negative voltage points numbered. Figure 1(B) is a similar representation of the horizontal signal wave. Note that the vertical signal has a positive maximum (2) and a negative maximum (6). The signal-voltage is zero at three points (0, 4, and 8). The horizontal signal likewise has a positive maximum (2), negative maximum (6), and is zero at points 0, 4, and 8. It is assumed that the positive vertical signal deflects the spot upward and that the negative vertical signal deflects the spot downward. Also that the positive horizontal signal deflects the spot to the right, and that the negative horizontal signal deflects it to the left.

Now, refer to Figure 1(C) which shows the pattern obtained when two such equal voltages, having zero phase difference, are applied to the scope plates. At the start, both vertical and horizontal voltages are of value 0. Therefore, neither vertical nor horizontal deflection voltages are present and the spot is at rest (position 0 on the screen). When the vertical voltage is at value 1, the vertical deflection component corresponds to point 1 on the vertical axis. But at this

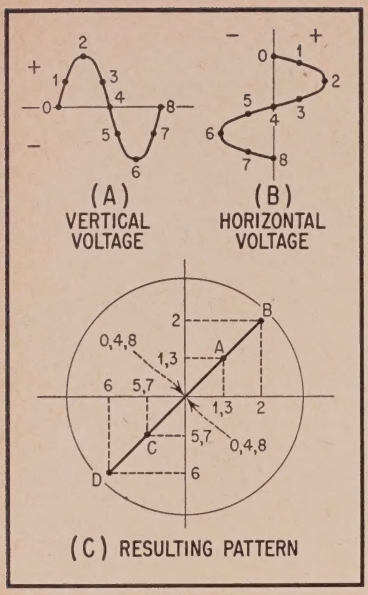


Fig. 1. 2 Equal Sinusoidal Voltages, 0° Phase Difference.

instant, the horizontal voltage is at its value 1, and the horizontal deflection component is at point 1 on the horizontal axis. The resultant of these two components moves the spot from rest to position A.

When the vertical voltage progresses to its value 2, the vertical deflection component corresponds to point 2 on the vertical axis. But at the same time, the horizontal voltage has reached its point 2, and the horizontal deflection component corresponds to point 2 on the horizontal axis. The resultant of these two components moves the spot to point B.

As the vertical and horizontal voltages fall back to their values 3, the resultant of these two components moves the spot back to A. And as they fall back to their zero value (points 4), the spot is returned to its center-screen position of rest.

Now, both vertical and horizontal voltages begin their negative excursion from 4 to 5 to 6 to 7 to 8, moving the spot from rest to C to D and back to C and to rest.

The result of this action is the 45-degree single-line trace DB. This tilted pattern always indicates that the vertical and horizontal voltages have the same frequency and amplitude and are of the same phase (0° phase difference). If the vertical-signal amplitude exceeds the horizontal amplitude, the tilt will be greater than 45°; and if the horizontal amplitude is the greater, the tilt will be less than 45 degrees.

When the two single-frequency signals have a 180° phase difference, a graphical analysis similar to that given in Figure 1 shows that the

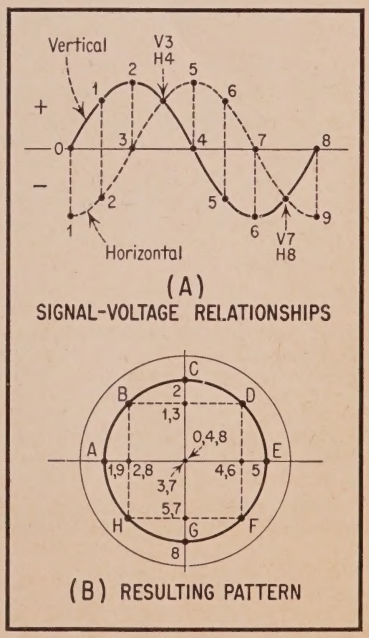


Fig. 2. 2 Equal Sinusoidal Voltages, 90° Phase Difference.

single-line trace will be tilted in the opposite direction — that is, to the left.

A similar analysis will show that if the two signals have the same frequency but are not in phase (or are not 180° or 360° out of phase), a single-line trace cannot result, but that the line will open (proportional to the phase difference) into a loop or ring.

Let us consider now the extreme case of a 90-degree phase difference between equal-amplitude signals of the same frequency. Figure 2(A) shows the relationships between vertical and horizontal voltages satisfying this requirement. For convenience in comparing, the two have been drawn on the same axis. Note that each voltage is at its maximum amplitude when the other is at its minimum, and vice versa. The vertical component is at zero at points 0, 4, and 8; the horizontal component at points 3 and 7.

Figure 1(B) shows the resulting pattern. When the vertical component is at its initial zero-voltage point (0), the horizontal component has its maximum negative amplitude (1). This causes the spot to be deflected to point A. When the vertical reaches amplitude 1, the horizontal falls to the less-negative value 2, moving the spot to B. At maximum positive vertical amplitude 2, the horizontal amplitude has disappeared to zero (point 3) and the spot is at C. Vertical 3 and horizontal 4 shift the spot to D, vertical 4 (zero) and horizontal 5 (maximum) to E, vertical 5 and horizontal 6 to F, vertical 6 (maximum negative amplitude) and horizontal 7 (zero) to G, vertical 7 and horizontal 8 to H, and vertical 8 and horizontal 9 back to the starting point A.

The resulting trace is a circle. This pattern indicates 90° shift between equal-amplitude signals of the same frequency. It also is the indication for 270° phase shift.

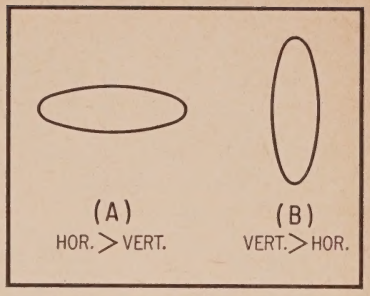


Fig. 3. Elliptical "Distortion" of the Circular Pattern.

When the horizontal and vertical signals have different amplitudes, the pattern will be elliptical rather than circular, the figure being elongated along the axis of dominant voltage. Figure 3 shows this condition. The horizontal ellipse depicting a larger horizontal voltage, while the vertical ellipse shows a larger vertical voltage. Tilting of either ellipse to the right or left indicates phase shift more or less than 90°, as will be explained later.

The two cases illustrated in Figures 1 and 2 show the two extremes between which we shall work in basic patterns. Each of these presentations is for sinusoidal voltages. Distortion in one or both signals will cause alterations of the pattern. Under some circumstances, one or both of the voltages can be of a waveform other than sinusoidal and the pattern will be more complicated. A graphical analysis, similar to Figures 1 and 2, will reveal the shape of the resulting pattern. Space does not permit a detailed consideration of the various presentations resulting from mixed waveforms.

Attention now will be given to the use of scope figures in frequency and phase measurements. In this discussion, the types of patterns obtained will be shown without going into an analysis to show why they result from

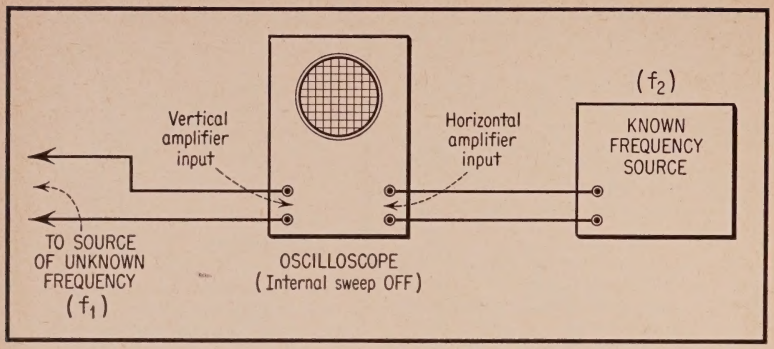


Fig. 4. Setup for Frequency Measurement.

the spot movement. Such analyses may be performed by readers so inclined who care to follow the techniques illustrated by Figures 1 and 2.

Frequency Checking

Figure 4 shows the equipment setup for checking unknown frequencies against a known frequency. The known frequency (f_2) may be supplied by a frequency standard, tuning fork, or electronic oscillator. This test method may be used for any frequency within the response range of the oscilloscope amplifiers.

When making the frequency test; set the oscilloscope controls as follows: EXTERNAL SWEEP off, SYNC to external, PHASING off or zero, INTENSITY, FOCUS, and ASTIGMATISM for the most legible trace.

It is advantageous for the known-frequency source to be an adjustable generator. The gain controls of the scope are set to give a pattern which covers enough of the screen for accurate interpretation. The known frequency (f_2) is adjusted carefully to give a stationary pattern. When the known frequency is adjusted close to the unknown (f_1), the pattern will rotate in one direction when f_1 is slightly lower than f_2, and in the opposite direction when f_1 is slightly higher than f_2. When f_2 is adjusted exactly to f_1 or to an integral multiple or submultiple of f_2, the pattern will stand still.

A stationary circle or ellipse (Figure 5A) indicates $f_1 = f_2$. The unknown frequency then may be read directly from the dial or calibration chart of the known-frequency source. For integral multiples of f_2, the pattern will consist of a series of horizontal circles or loops, as shown in Figure 5, B to E. When f_1 is an integral submultiple of f_2, the loops will be vertically arranged, as in Figure 5, F to I.

With a single, fixed standard frequency (f_2), it is an easy matter with this method to measure frequencies between $1/10\ f_2$ and $10f_2$. Thus, a 1000-cycle standard frequency will permit measurement of all integral frequencies between 100 and 10,000 cycles. Higher orders become more difficult, if not impossible, to measure because of the difficulty of counting the loops on the relatively narrow screen of the oscilloscope. However, it is a simple matter to change f_2 in appropriate steps. Thus, only three standard frequency (f_2) values of 100 cycles, 10 kc., and 1 Mc. will permit measurement of all integral frequencies from 10 cycles to 10 megacycles.

It should be pointed out that unequal amplification in the vertical and horizontal channels of the scope will result in elongation of the pattern

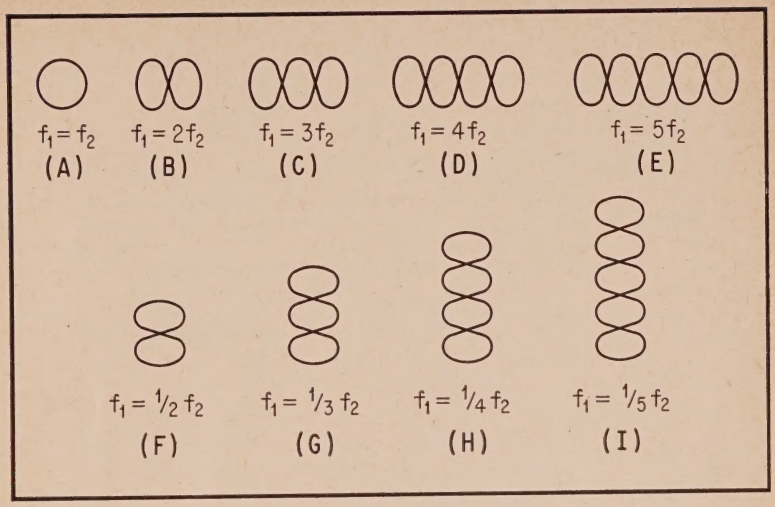


Fig. 5. Frequency-Test Patterns.

loops in the direction of the dominant signal voltage. Thus, a higher vertical amplification will stretch the loops vertically, as in Figure 3(B); and a higher horizontal amplification will stretch the loops horizontally, as in Figure 3(A).

Close circularity or ellipticity in the pattern loops depends upon phase characteristics of the scope amplifiers. If the vertical and horizontal amplifiers have the same constant overall phase characteristics, the loops will be uniform and without tilt. The circle of

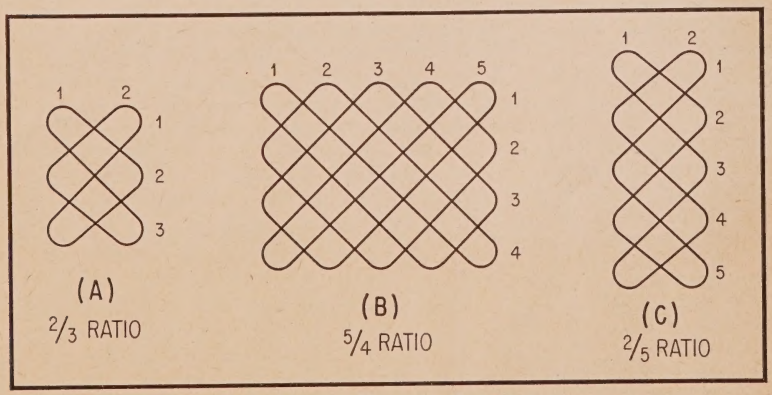


Fig. 6. Complex Frequency-Test Patterns.

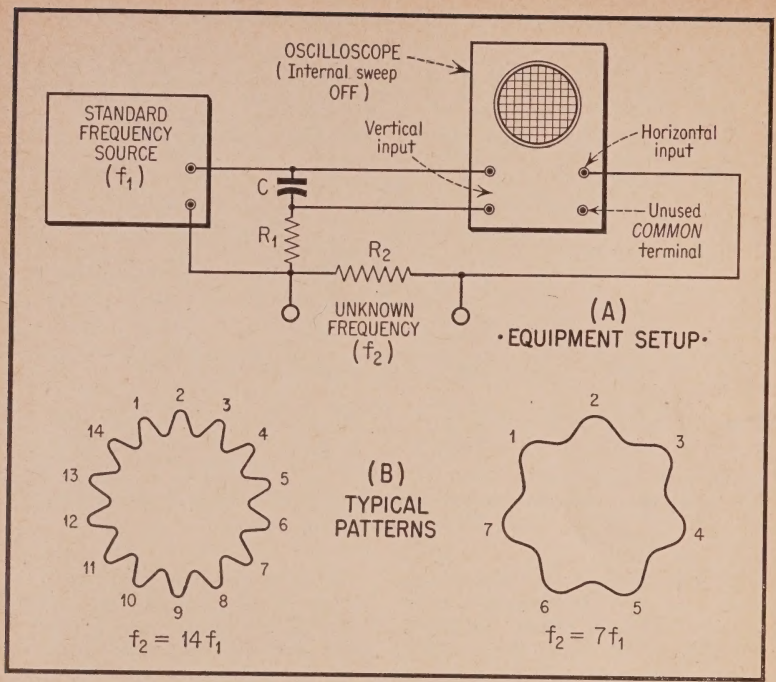


Fig. 7. Setup for Gear-Wheel Frequency-Test Patterns.

Figure 5(A) thus corresponds not only to identical input frequencies, but also to 90° phase shift, as was noted earlier.

The simple frequency-test patterns shown in Figure 5 correspond to integral ratios between the unknown and standard test frequencies. A test utilizing patterns of this kind for indication is restricted to exact multiples and submultiples of the standard, known frequency. It is not possible to check accurately and quickly "in-between" frequencies by this scheme. The latter frequencies give complex patterns, however, which permit measurement in terms of the standard frequency when the operator understands their interpretation. Figure 6 shows several examples of such patterns which may be obtained. The frequency ratio indicated by the stationary pattern is determined by counting the ends of the horizontal loops along the top or bottom of the image, and of the vertical loops along the left or right edge. Thus, in Figure 6(B), we count 5 horizontal loops and 4 vertical ones to obtain a frequency ratio of 5:4.

When frequency ratios are higher than 10 to 1, test patterns such as those shown in Figures 5 and 6 have so many loops that they do not afford good accuracy, nor are they convenient to use. It is exceedingly difficult to count so large a number of convolutions. Figures 7 and 8 show arrange-

ments which are better suited to high ratios.

In Figure 7(A), a 90° phase-shift network (CR_1) is employed with a standard frequency source, f_1. This arrangement produces a circle trace on the scope screen. When the unknown-frequency (f_2) is applied across resistor R_2, the circle becomes modulated with loops, as shown in Figure 7(B). The standard frequency then is multiplied by the number of loops (or teeth) in this "gear-wheel" pattern to obtain the unknown frequency. The pattern wheel will rotate in one direction or the other when the two frequencies are close to integral values and will stand still when exact integral values are reached. Resistor R_2 is 1000 ohms. Capacitance C and resistance R_1 are chosen for 90° phase shift at standard frequency f_1. C can be chosen 0.1 to 0.25 ufd. and R_1 made variable to cover a range of standard frequencies.

At very high ratios, the gear-wheel pattern even becomes difficult to handle. An improvement is obtained by the "spot-wheel" method illustrated in Figure 8. Here, the 90° phase-shifting R-C network is used, as in the gear-wheel circuit, but without the 1000-ohm resistor, and the unknown-frequency signal is applied to the intensity-modulation (Z-axis) input of the scope. The internal sweep is switched off. The wheel pattern of Figure 8(B) is obtained, and the unknown frequency (f_2) obtained by multiplying the standard frequency (f_1) by the number of dots or segments around the circle circumference. The lowest readable intensity must be employed, otherwise the spots will be

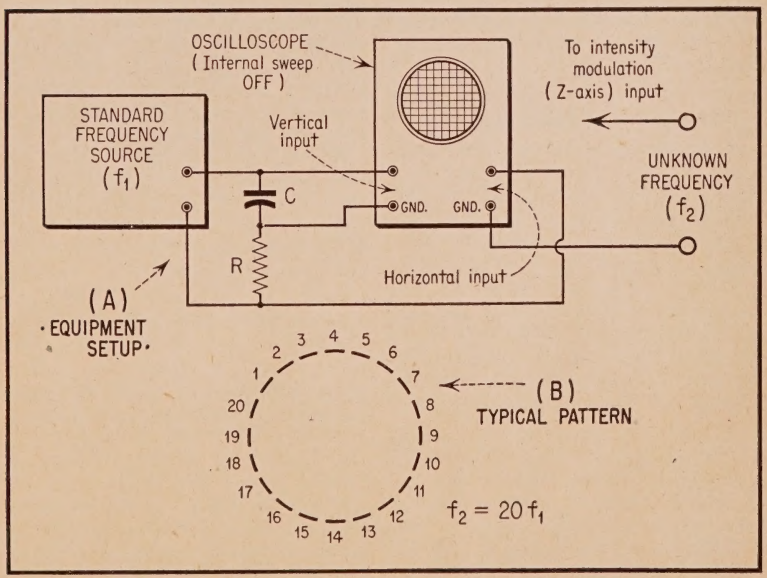


Fig. 8. Setup for Spot-Wheel Frequency-Test Pattern.

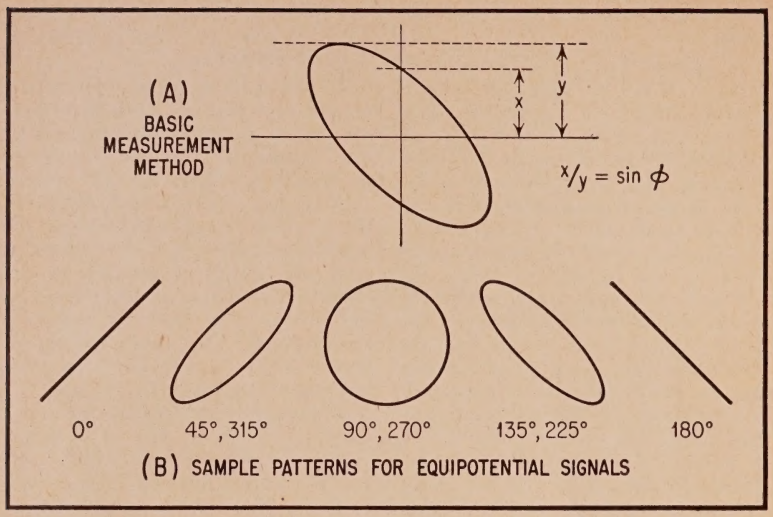


Fig. 9. Phase-Difference Test Patterns.

obscured. The wheel will spin until f_1 and f_2 are in exact integral relationship.

Measurement of Phase Difference

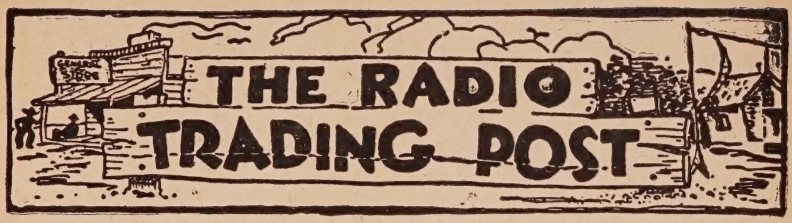
When two signals have the same frequency, their phase difference may be checked by applying one to the vertical plates and the other to the horizontal plates of the scope. If one signal component is a current, a voltage signal may be obtained as the drop across a low resistance through which the current is made to flow. If the scope amplifiers are used, the latter must have identical phase characteristics for accurate measurements.

The spot first is set to exact center of the screen. The internal sweep of the scope is switched off. When the signals are applied, a pattern somewhat similar to Figure 9(A) is obtained. The vertical height (y) of the pattern from center-screen is measured, and the vertical distance (x) of the intersection of the trace with the vertical axis. The quotient x/y equals the sine of the phase angle. By reference to a table of trigonometric functions, the angle corresponding to this sine may be determined.

When the two signals have the same amplitude, the phase patterns often can be recognized and identified without detailed measurements. Figure 9(B) shows some of the characteristic patterns obtained with such signals.

Effect of Distortion

The discussions in this article have been limited to sine-wave signals. When distortion of either test signal is present, the uniform, even-lined patterns illustrated will not be obtained. The amount of bending, slicing, or kinking present will depend upon the type and magnitude of the distortion. Large amounts of distortion or modulation introduce considerable inaccuracy in phase measurements, probably more than in frequency measurements.



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FOR SALE — Feiler 5" scope, stethoscope probe and earphone connections, incl. probe, almost new, $45. Albert F. Hanschke, 46 Oak St., Wellsville, N. Y.

FOR SALE — EV-velocity mike, l. n., model V-2, $32; 16" radio transcriptions music shows, $1.50 ea.; Brush PL-20 professional pickup with equalizer, $10; mike mixer $5. Want professional tape recorder. Victor Maycher, Box 485, Passaic, N. J.

WANTED — Variable condenser National TMA-150-A 6000 v. rating. Fred Norton, 1450 Norman Ave., Muskegon, Mich.

FOR SALE — Tape recorders: Webcor model 210, Pentron model 9T3-C, l. n., $150 each plus shipping charges; 50 rolls 1200' plastic base recording tape, $2.50 each. F. Tantillo, 17 Orange St., Abington, Mass.

WANTED — Model 107 Oak Ridge miniature Dyn-o-tube tester in good cond., complete with book type tube chart, preferably one bought since 1951. J. W. Beatty, 25 Westside Court, Lexington, Va.

WANTED — 6 - 110 v. amp.; also hi-power 50 w. 110 v. or larger amp. Vernon Blaine, Gary, S. D.

FOR SALE — Well located radio and TV sales and service business. Overton Bray, Box 276, Paul, Idaho.

WANTED — FM 152 to 162 Mc. Would pay cash or trade 16 mm. silent movie projector, six 300 ft. reels of WWII and 30 x 40 screen. H. Kuell, 18½ Thomas St., Newark, N. J.

WANTED — 16 mm. Bell & Howell sound projector, model 156. State cond. and price. Horace O. Pease, 144 Manson Ave., Kittery, Me.

SELL OR SWAP — Portable phonograph, light weight, spring-driven motor, exc. cond., $12 COD or trade for what have you? Y. Brevda, No. 1130, Y.M.C.A., 55 Hanson Pl., Brooklyn 17, N. Y.

WANTED — BC-464 radio control drone target plane receivers, any cond. if audio chokes are intact. Frank Schwartz, 204 6th Ave. North, Nashville 3, Tenn.

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FOR SALE — Riders 4 to 13, incl., $55; ATR rectifier supply 6 v. at 14 amp., 14 v. at 7 amp., $20; Supreme model 581 sig. gen., and freq. mod., $20; Supreme 81 tube and set tester, $15. W. E. Menehan, 7416 - 5th Ave., North Bergen, N. J.

SELL OR TRADE — RCA Voltohmyst Jr., fair cond.; 1940 Buick sonomatic radio, and 1/3 HP motor. Best offer or trade for 7" TV, outboard motor, gasoline motor. Cass Radio and TV, 840 Cass Ave., Kingsford, Mich.

TRADE OR SELL — Motorola car radio, model 309, needs filter condenser; Philco car radio model 806; Philco 10" TV, model 1001, needs repair in sync circuit. All tubes included. Trade for VTVM and sig. tracer in good cond. Anthony Cincotta, 541 Union St., Carlstadt, N. J.

FOR SALE — Stancor ST203A Xmtr., converted to 75M, A-1 cond.; Mallard 75M coil for mobile; amp. from juke box, 4 tube plus rectifier, made by Lear, l. n.; BC-457 and 696 built in aluminum box with power supply. Harlan Dewitz, Wisner, Neb.

FOR SALE — Weston 0-50 M.A., model 301, round case, l. n., $5.50 postpaid. L. Weinreb, 151 - 09 34th Ave., Flushing, N. Y.

FOR SALE — Crystal calibrator and monitor, type CGQ for TBX-8 radio equip., $6. John Wohlrab, 245 Parkside Ave., Buffalo 14, N. Y.

FOR SALE — Well-equipped radio and TV sales and service shop, established 16 years in very good location, $7,000. Also four room apartment to rent. Art Radio Service 1422 - 7 Ave., Rock Island, Ill.

FOR SALE — 3 transcription arms, Pickering model 161M, diamond stylus .0025, $210; 3 equalizers for 163A Pickering, $100; Presto 39-B three-stage pre-amp. with supply, $75. Equip. in exc. cond. Chester Lewicki, 2208 S. Millard Ave., Chicago 23, Ill.

SWAP — Hallicrafter S-40, or Sylvania 131, 3" scope, for Riders manuals, or Sams. H. D. Williams, 204 Chestnut, Gadsden, Ala.

SELL OR SWAP — Eico scope, needs 5BP1; Service magazines. Cash or will trade for binoculars, outboard motor, hand guns, or ?? James E. Munson, Box 186, Pembroke, Me.

FOR SALE — 522 receiver, Xmitter with power supply in cabinet, cables, mike, converted to "2", $40; Morrow 3BR mobile converter, $35; 16-element 2-meter beam, $6; Yagi TV antenna, assorted books and magazines. Philip L. Snyder, Glenida Blvd., Mahopac, N. Y.

FOR SALE — Back loaded, folded horn speaker cabinet with two 12" speakers, $19.90; two-speed tape recorder, pre-amp., case, $69.90; three-speed record player, $14.90. J. C. Davis, 9014 North Laramie Ave., Skokie, Ill.

SWAP — Amperite PGH mike, 12" PM speakers, RCA portable phono changer, Sparton battery radio, refrigeration equip. Want SX-25 receiver or equal. George H. Hague, 6 Carver St., Fall River, Mass.

SELL OR TRADE — Eico sig. tracer and condenser checker; Heath voltage calibrator; Hickok 288X sweep gen. Need E-200C, 4.5 Mc. and 10.7 Mc. crystal. John A. Kimm, 934 Judson St., Evansville 13, Ind.

SELL OR TRADE — GE rotary converter 115 v. DC to 80 v. AC, 200 w. and ATR inverter 110 v. DC to 110 v. AC, 350 w., continuous. Both in A-1 shape. John Hricinak, 2038 S. Croskey St., Philadelphia 45, Pa.

FOR SALE — Two BC-645 transceivers in orig. boxes, includes instructions and diagrams for converting to Citizen's Band, $10 each, plus shipping. E. E. Erwin, 1840 E. 37th St., Indianapolis, Ind.

WANTED — Used correspondence course in TV service at reasonable price. Herman Grohman, 4329 Broadway, New York 33, N. Y.

WANTED — Sylvania's book, servicing radio and television with a vacuum-tube voltmeter. Art Henrich, 10 Earl St., Kitchener, Ontario, Canada.

WANTED — BC-348 receiver and schematic for same. State price and cond. Felix M. Pyrz, 1536 Sobieski St., LaSalle, Ill.

SELL OR TRADE — Fieler TS-9 VTVM, $25, Emerson consolette 10" TV $25, or trade VTVM or TV for tube tester. Frank Prestel, 3747 N. Olcott Ave., Chicago 34, Ill.

FOR SALE — RCA 3" scope, model 155C, l. n., $65; Radio City Products tube tester, model 314, perfect cond., $30; Heathkit VTVM, model V-5, exc. shape, $25; Subracco 10-meter mobile Xmitter, $30. Eugene Adams, 755 Delafield Ave., Staten Island 10, N. Y.

FOR SALE — Hallicrafter S-40, l. n., $50. Peter Martin, 398 East 152 St., Bronx 55, N. Y.

FOR SALE — 12" prewar Rek-O-Kut overhead lathe type recording mechanism, less cutting head, General Industries heavy-duty recording motor, heavy 12" turntable for above unit 78 RPM, $45. Exc. cond. M. Maillet, 5 Emerald St., Gardner, Mass.

WANTED — Heathkit sweep TV alignment gen., TS-3. W. Stauffer, 50 - 15th St., Buffalo 13, N. Y.

WANTED — RCA crystal calibrators, stock nos. 157 and 9572. Have for sale used auto radios, Clough-Brengle model 127 scope, and freq. modulator in good cond. Paul Capito, 637 West 21 St., Erie, Pa.

WANTED — Used FM police or taxi mobile transmitters and receiver units. Ralph Villers, Box 1, Steubenville, Ohio.

FOR SALE — Kiver's "Television Simplified," l. n., $4 COD. Sidney Cutler, 1954 Unionport Rd., New York 62, N. Y.

FOR SALE — McMurdo-Silver sweep sig. gen., model 909., perf. cond., $25. Paul W. Eldridge, 14425 S. Normal Ave., Chicago 27, Ill.

SELL OR TRADE — Hardly used (53) Heathkit scope, for good Dynamic tube checker, which covers all tubes including CRT's or $50. Local only. Mac Sawransky, 314 E. 206th St., Bronx 67, N. Y.

WANTED — IRC or Ohmite resistor cabinets (cabinets only). State price, cond., etc. T. E. Shaw, 3-20 27th Ave., Astoria 2, L. I., N. Y.

SWAP — L. n. GE scope, model CRO3, for good tube-set test, S-W receiver, or what have you? H. J. Murray, 2709 W. 156 St., Gardena, Calif.

FOR SALE — GE AM-FM sig. gen., model YGS-3, 100 Kc. to 150 Mc., l. n., $62. Dave's Radio, 1316 - 42nd St., Brooklyn 19, N. Y.

SELL OR SWAP — Books: Handbook for Electrical Meterman, Relay Handbook, John F. Rider's Servicing Superheterodynes, Servicing Receivers by Means of Resistance Measurement, Automatic Volume Control. Kauer Radio Service, 142 Mohr Ave., Buffalo, N. Y.

WANTED — Dial plate in perfect cond. marked 1.5-3 Mc for SCR 274 receiver. Royce I. Heintz, 3500 Woodmoor Rd., Baltimore 7, Md.

FOR SALE — National SW-54 receiver, l. n., $35; Teletone 7" TV, l. n., $30. Lloyd Teran, 23 Hosmer St., Mattapan 26, Mass.

SWAP — 7" TV booster, meters, antenna and other items for guns. Thomas R. Rohland, Route 3, Martinsville, Ind.

FOR SALE — Radio City Products model 802N Multitester, A-1, $25. Prefer local contact. Rocco Sciarrone, 300 - 5th Ave., Brooklyn 15, N. Y.

WANTED — HQ129X, NC200, or similar receiver. State price and cond. Margaret Cauffield, RD 1, New Florence, Pa.

FOR SALE — Like new T23/ARC-5 100-160 Mc. coverage, complete with tubes, $26 postpaid. Milton Kalashian, 2 Congress St., Newburyport, Mass.

WANTED — Instruction manual for Army version type Panadaptor receiver model SA-3 type T-200. State price. John Christy, 14553 Dickens St., Sherman Oaks, Calif.

TRADE — Dynamic Super-charged arc-welder, model 75D, l. n., instruction; Heath Dynamic tube checker, model TC1, perfect cond., with manual, for 1 thru 13 vols. Riders troubleshooters. R. H. Blanshaw, 626 W. Scott St., Youngstown, Ohio.

FOR SALE — Regency DB-520 Booster $9.95; Alliance AB-5 Booster $9.95; Channel Master Channel 6 Booster $7.95; all in orig. cartons. Virginia Radio Supply Co., 715 Henry Ave., Charlottesville, Va.

FOR SALE — Alliance "Tenna Rotor" $20; polaroid filters 10" 12" 16", $1 each; I. n. Dumont TV cabinet 12" consolette $15. Ted Waseki, 106 Beech St., Rutherford, N. J.

FOR SALE — RCA-153 Sig. gen., also German table model radio. H. Latko, 1922 Dickens, Chicago, Ill.

WANTED — "Minifon" pocket-size wire recorder. Must be reasonable. Alex Siegel, 1516 Shakespeare Ave., New York 52, N. Y.

FOR SALE — Argus C3 camera with leather case; Carter dynamotor 350 v., 150 MA., Command transmitter; 2-station intercom; Kelsey 9 x 13 printing press. Want type and printing supplies. C. Keeler, 66 Franklin St., Port Jervis, N. Y.

FOR SALE — 10" Westinghouse mahogany table model, 4-196A-DX, designed for fringe area, 28 tubes, good cond., $29, express charges collect. Jones Radio, 1115 Rambler Ave., Pottstown, Pa.

TRADE — Complete RCA TV model TC166, all tubes including picture tube 16" or 19" less cabinet, for $50 or RCA WV97A, complete with probes. Local trade. John Kozma, 1665 Stadium Ave., New York 61, N. Y.

WANTED — Position in warm dry climate. Have fifteen years' experience as radio mechanic. Anthony Bruno, 6812 - 11th Ave., Brooklyn 19, N. Y.

WANTED — 20 meter rotary beam, with or without rotator. Have Eico condenser checker, unconverted 7-9.1 Mc. meter ARC-5 and/or cash. Dennis O'Day, 530 West 10 St., Juneau, Alaska.

WANTED — Browning AM-FM tuner. Would accept Fisher or Craftsman of top quality. Also Bugen DB20 amp. L. E. Salom, 724 Hunting Tower W., Alexandria, Va.

SWAP OR SELL — Burroughs adding machine, 8-column with carriage; man's ice skates, Dunne Premier and English riding boots, size 7½. Want VTVM, sig. gen., FM radio, etc. D. Rosenberg, 7101 Colonial Rd., Brooklyn 9, N. Y.

WANTED — Argus C-3 camera, Hallicrafter S-38, plastic base tape, Hi-Fi equip., good enlarger. J. T. Wentworth, Rt. 9, Box 467B, Springhill, Ala.

TRADE — Zenith transoceanic portable radio for FM-AM radio or tuner. Alvin Walker, 1202 N. Broadway, Milwaukee, Wis.

FOR SALE — Very good Pentron tape recorder, cost $170, will sell for cash to best offer. J. M. Parsons, 2128 Catalpa Drive, Dayton 6, Ohio.

NOTICE — Will "PZ" of Gary, Ind., in answer to card about 30-50 Mc. rcvr. send name and address again. Ted Fisher, 1385 'H' St. N. E., Washington 2, D. C.

WANTED — 3-speed home phonograph, good cond., but cheap, TV antennas, Channel 60 Yagi, table model radio. Bill Brasie, 420 Adams, Owosso, Mich.

WANTED — Antenna scope, Riders manuals, No. 9 and up. Gustave M. Mondrush, 600 Beechmont Drive, Dearborn Hills, Mich.

FOR SALE — Feilers Electroscope model TS-8, $10. Albert Lord, 9 Chestnut Ave., Saylesville, R. I.

SELL OR SWAP — Back issues of QST, IRE Proceedings, Radio and TV News, Service. Some dated for 1924. I. Sass, 1859 62nd Street, Brooklyn 4, N. Y.

WANTED — Will buy outmoded disc recorders and equip., especially want overhead lathes and cutters. Send for swap list. Fred Keller, Memory Lane, Linlithgo, N. Y.

SELL OR TRADE — Stewart Warner rcvr., model 1859, 3 band, 11 tubes, 18 push-buttons, motor driven tuning, 14" copper speaker, relays need adjust. Schematics included. Martin Cademy, 1535 University Ave., Bronx, N. Y.

SELL OR TRADE — Unused Heath TS-2 sweep gen., Heath model 0-6 scope, Dumont 24BP4 tube, Webster 78 RPM changer, 1940 Pontiac radio, Hoffman & Philco 12½" TV receivers (chassis only). Want 35 mm. slide proj. R. Heinzelman, 4821 Coolidge Ave., Culver City, Calif.

WANTED — Popular Science monthly magazines, issues of 1939 to 1944. State price for all or part. Joe Coffield, 1402 West 4 St., Brooklyn 4, N. Y.

WANTED — Test equip., give price in reply. A. I. Bryden, 17 Beacon St., Chelsea 50, Mass.

WANTED — Hi-Fi equip., swap camera photographic equip., or pay cash. M. Herbstman, 97 - 25 64 Ave., Rego Park, Queens 74, N. Y.

SELL OR TRADE — BC-375E Xmitter; RM-29 remote controls; BC-348Q rcvr. Want MN 26C compass rcvr.; DU-1 loop and amp.; ARB (CRV 46151) rcvr.; HT-14 or SCR-543 marine transceiver. Wm. Hansen, 165 Silverbook Ave., Niles, Mich.

WANTED — 12KP4 picture tube in good shape, no dogs; also E200C generator. Have cash, 25 w. sound system, 16 mm. sound projector, etc. John Arnold, Box 84, Bluffs, Ill.

FOR SALE — L. n. Transvision Cathode Ray tube tester-reactivator with instructions, hardly used. First $10, shipped COD. Ben's TV Service, 680 Clifford Ave., Rochester 21, N. Y.

SELL OR TRADE — Power Supply, 750 v. at 250 Ma., screen, filament, $22; XE-10 NBFM Exciter, $10; VFO, 2.6 to 9.0 Mcs., continuous, $7, or best offers. Need FM tuner. R. Levy, 608 E. Seventh St., Brooklyn 18, N. Y.

FOR SALE — GE SCR 287A Xmitting equip. in orig. crate, including tuning units and dynamotor. You arrange delivery, cash only, best offer. M. Chernow, 715 Bullock, Ave., Yeadon, Pa.

FOR SALE — Weston tube checker, $25; Precision VOM, $35; C-D condenser tester, $12. Consider swap for test gear. Herbert Piller, 749 Beck St., Bronx 55, N. Y.

FOR SALE — RCA 50 w. amp., MI-4288L, or trade for WV97V RCA Voltohmyst. A. L. Friel, 151 Chestnut St., Watertown, N. Y.

WANTED — Flyback for 10" and 12" TV, also 7DP4 or 10DP4 TV tube, old camera with f1 or better lens, or 32 mm., used. Have radio parts, tubes to swap for what have you. L. Olsen, 5734 Waring, Los Angeles 38, Calif.

FOR SALE — BC348-Q comm. receiver converted to 117 v. AC excellent cond. Highest offer or what have you? Edward G. Tanrath, RR 2, Lake in the Hills, Algonquin, Ill.

FOR SALE — Precision EV-10-P VTVM, perfect, $60; Precision E-200-C sig. gen., perfect, $35; Clough-Brengle 79C audio gen., good, $20; CREI radio, broadcast, TV, engr. correspondence course, complete, exc., $50; Heavy 16" turntable, $5; all FOB. Hal Magargle, 4812 Cooper Lane, Hyattsville, Md.

WANTED — Swap evening and weekend work in exchange for opportunity to learn radio and TV in New York City. Also want "Elements of Radio" by Wm. and A. Marcus and "Radio & Television Repair" by John Markus. Must be bargain priced and in good condition. Isaac Starkman, 2175 Morris Ave., Bronx 53, N. Y.

FOR SALE — Barrard RC-80 3-speed record changer, new cond., $37.50 FOB. James P. Youngren, 422 Gregory, Rockford, Ill.

WANTED — Hickok 288X, Sylvania 216, or similar FM and TV sweep alignment equip. State price and age. Boyd Mallett, 1455 Harrod Ave., Bronx 70, N. Y.

WANTED — BC603 receiver or any surplus receiver for 30-50 Mc. FM and 152-174 Mc. FM. J. P. Hyde, Manassas, Va.

FOR SALE — 6V6 - 6L6 - PP807 rig with dual power supplies. Oversize parts, metered, all stages tuned, professionally constructed and operating all bands. $85 cash including coils, tubes. Mildred Howell, Box 126, Lumberton, N. C.

SWAP — Have Kodak 35 mm. camera; want tape recorder, scope, sig. tracer, grid dip meter, 813, 829, 832 tubes, transmitting parts. W. M. McDonald, 86 Appleton St., Providence, R. I.

SELL OR SWAP — L. n. Videola TV slave set, less CRT, 10", $40 cash or late type TV test equip. W. R. Batten, 1536 Crosby St., Rockford, Ill.

WANTED — 1948 and 1949 issues of "Scientific American" magazine. W. E. Keder, 135 Robinson St., Pittsburgh 13, Pa.

SELL OR SWAP — Stancor No. 752 power pack, 6 v. DC output, guaranteed l. n. in orig. carton. What have you to trade or best cash deal. Walt Bartell, 1107 N. Western Ave., Chicago 22, Ill.

WANTED — National HRO. State model and price. Robert Becker, 200 South Williams St., Westmont, Ill.

FOR SALE — Eico sweep gen., factory wired, $35; Dumont RA101 20" TV FM-AM-SW less cabinet, $50; RCA 621 7" TV, good cond., $28. Prefer N. Y. City area. Jack Bechtler, 23 - 79 206th St., Bayside 60, N. Y.

FOR SALE — L. n. RCA WV-87A $100; and Supreme 616 tube checker $45; 315 Simpson sig. gen., $50. Cash only. Want Oak Ridge testers for cash if reasonable. Trade good radio TV shop for good large trailer. Morgan's Radio and Television, 562 Florida Ave., Jacksonville, Fla.

WANTED — One 3KP1 or 3KP4 picture tube, new or in good cond. State price or will trade. Arjay Radio Service, 1929 So. Spring St., Springfield, Ill.

FOR SALE — Precision tube tester, model 954G, exc. cond., $65. James Cunningham, 25 - 34 44th St., Long Island City 3, N. Y.

SELL OR SWAP — Presto overhead recording mechanism, less head and turntable, and G.R. 726A VTVM. E. S. Bednar, 81 Lincoln Ave., Carteret, N. J.

FOR SALE — Model 5S Unidyne Super Cardoic mike with low, medium, and high imped. Sw. including stand., exc. shape. Make offer. Also have two Vibropacks 300 v. at 100 Ma. each. E. Bowley, 31 - 19 43rd St., Long Island City 3, N. Y.

SELL OR SWAP — Sparton model 60, SW converter, good cond., two 809's and two 866 Jr's, l. n. Want 60 w. model Xmfr. Best offer. H. L. Allison, c-o Kearby's Radio Shop, Walnut Ridge, Ark.

TRADE — Kato-Lite 115 v. AC, 5,000 w. 60 cycle, self-excited, new cond., gen., no power unit, for complete mobile rig with Elmac transmitter, Gonset converter. W4YPC, 1008 Willbanks Ave., E. Gadsden, Ala.

WANTED — Circuit of model 400 Triumph tube tester, hand-drawn or printed, loan or buy, also old type Superior testers (before 1940) any condition, VOM, VTVM, tube testers, utility testers, etc. Sales-Service, 5734 Waring, Los Angeles 38, Calif.

SELL OR TRADE — Refrigeration course, for TV and radio course, also interested in condenser tester and late model AM and FM and TV sig. gen., or scope. George E. Buck, 224 Waverly St., Providence 9, R. I.

WANTED — Xtal controlled receiver to cover Marine frequencies. Must be complete as possible 12 or 24 v. input. Advise cond., size, and best price. Sid Friedman, 85 Newman St., Hackensack, N. J.

SWAP — Complete DeForest radio and TV course, less kits, in very good cond. for good refractor or reflector telescope. John Romaine, 152 E. 123 St., New York 35, N. Y.

WANTED — FM or TV factory wired test equip. State price, age, and condition. Lloyd Lynch, 1390 Clinton Ave., Bronx 56, N. Y.

WANTED — 0-50 Ma DC 3½" panel meter (round), RCA model 630TS TV set, Precision or Hickok tube checker. Must be reasonable for cash. W. E. Jones, 10 Main St., Bowmansville, N. Y.

FOR SALE — FAS Bass enclosure with GE 1201A speaker $25; GE 1201A spkr. $10. Local only. Write first. Eugene Roy, 5 Hillside St., Haverhill, Mass.

WANTED — Supreme model 688 Audolyzer, l. n. Have for sale used auto radios, and AC motors. Paul Capito, 637 W. 21st St., Erie, Pa.

FOR SALE — CREI radio course, 68 lessons in 12 hard binders, some never used, $59; QST's 1941-50, $2 per year; Navy intercom, NV14 T1-A 110 v. AC, tubes and power, $25. A. C. Livingstone, 12 - 01 Ellis Ave., Fair Lawn, N. J.

FOR SALE — Mallory rectifier power supply, type 28VA15M1, 28 DC at 15 input, 10 continuous amps., primary 115 v. AC, 60 cycles. Weighs about 100 lbs., $75. E. Tate, 6564 Broadway, Cleveland, Ohio.

FOR SALE — Heathkit TV alignment gen., TS-2 with instruction book and prints, $29; UTC LS-55 Hi-Fi O.T. $17; Stepdown Xfmr 200:240, 115 v. 50-60 cycles 500 VA $10; Webster 56 record changer 78 RPM with GE mag. cart., $15. All l. n. C. L. Goebel, 221 W. 233rd St., Bronx 63, N. Y.

TRADE — Instructograph with ten tapes, Hallicrafters S-38, radio tubes, l. n., for Hickok or Rider Chanalyst, scope suitable for TV. Must have instructions. Also want VM950 or later model. John Simmons, 520½ 10 St., Alamosa, Calif.

WANTED — Riders radio manuals 1 to 17. H. E. Staples, 263 Bowers St., Jersey City 7, N. J.

FOR SALE — Hickok Traceometer model 156, l. n., with test cables and instruction manual, $125. W. W. Marsh, 219 Girard Ave. No., Minneapolis, Minn.

FOR SALE — Pilot model T601 FM tuner, in exc. cond., $18 postpaid. Milton Kalashian 2 Congress St., Newburyport, Mass.

WANTED — Nearby summer job in radio. Would like to build kits such as Eldico or Heathkit and sell them unused, at slight profit. Any buyers? J. L. Snider, Jr., Weston Road, Lincoln, Mass.

TRADE — Hallicrafter S-40-B, exc. cond., for FM and AM tuner (R.C. and Collins, etc.) and wire recorder or basic tape mechanism. Louis S. Venturelli, 224½ 21st St., Brooklyn 32, N. Y.

WANTED — 5" or 7" Heathkit or Eico scope and sweep gen., with inst. in good operating cond. and reasonable. Ed Hagmaier, Box 211, Clymer, Pa.

FOR SALE — Picture tube for scope, Nos. 7D3-19 and 7GP1, l. n., $7. Buyer must pick up tube. John C. Perino, c-o Ernest Meyer, 1453 Merry Ave., New York 61, N. Y.

FOR SALE OR TRADE — Tubes: 833A, 813, 866, 211, 2E26, 957, and 9003; Superior 450 tube tester; Genemotor 12V 500 v. 50 mil. output. Want mobile Xmtr. and converter or surplus gear. Charles H. Russell, Fayetteville, Ala.

SWAP — Two Craftsmen and one Pilot Hi-Fi amps., two preamps., Pilot Transceiver, VOM, GE FM tuner, Masco 5-station intercom, for guns, binoculars or R scopes. Bill Bockman, 400 Single Ave., Collins Park, Del.

FOR SALE — Pair each 250TH's, 100 TH's, 832's, A-1 cond. Make offer. R. W. Heckbert, 30 Magoun Ave., Medford 55, Mass.

FOR SALE — Simpson model 555 tube tester; E-200-C sig. gen.; TS-7 Cathode-Ray scope; Heathkit VTVM V5; Triplett model 666HH Volt-Ohm-Milliammeter. All l. n. Oswald Maillet, 5 Emerald St., Gardner, Mass.

SELL OR TRADE — CRT's 2BP1A, 5BP1, 5LP7, 7JP4, 7BP6, 10BP4, 10FP4 (alum.), 12" alum., 12GP7, 12DP7, 15AP4, 16TP4. All A-1 cond. Need 5LP1, VTVM or ?? Seymour Harris, 758 Princeton Road, Franklin Sq., L. I., N. Y.

FOR SALE — Astatic "Channel Chief" model AT-1 (four tube) TV booster, $15. Exc. cond. John E. Farrier, 220 Bird Ave., Sidney, N. Y.

FOR SALE — 5 cents each, plus postage, back issues Radio, TV and Electronic magazines. Send for list. Ben Green, 5126 Riverton, North Hollywood, Calif.

SELL OR SWAP — Several 110 v. AC 1/6, 1/5, 1/4 HP used motors, $5 each. Schneider, 9409 Ave. A, Brooklyn 36, N. Y.

WANTED — Single sideband equip. Cash or trade Lysco 600 transmaster with built-in TVI Lo Pass Filter. L. W. Holmes, 1629 6th St. S.E., Minneapolis 14, Minn.

WANTED — For cash, roll chart attachment part No. 9525, for NRI professional model 67 tube tester, made by Triplett Mfg. Co., Bluffton, Ohio, distributed by National Radio Institute, Washington, D. C. State price in first letter. Derry's Radio Shop, King's Mountain, Ky.

FOR SALE — Philco 37-690 receiver, needs new speaker and power trans. No reasonable offer refused. Joseph Jorden, 931 N. Harvard Ave., Villa Park, Ill.

FOR SALE — Pair DNE Vocatrons wireless intercoms, never used, $97.50 value for $70. George Bobik, Box 441, Monongahela, Pa.

FOR SALE — Complete test setup for shop or student at less than kit cost: Eico Deluxe 315 sig. gen., 360 sweep gen., and H25 scope. All expertly wired and accurately calibrated, $100 cash. Edwin Quinn, 19025 Hartland St., Reseda, Calif.

FOR SALE OR TRADE — Sound power phones, BC-454, electric drill, novice transmitter, RI-ARRI, electric shaver, ohmmeter, etc. Need good 12" speaker and 2 meter equip. Walter Smith, Box 26, Charlotte, Mich.

WANTED — ARC-4 receiver head and plug out of mounting rack; technical manuals for TS10/APN, TS-16/APN, ARC-4, SCR-808, and GE SR2A mobile FM receiver. Mike Peterhans, Pond Farm, Guerneville, Calif.

SELL OR TRADE — Wilcox-Gay disc recorder model 6A10 two-speed, 78 and 33⅓ RPM, for E-200-C Precision sig. gen., or similar, in A-1 cond. W. D. Poole, 32 Montgomery St., Cartersville, Ga.

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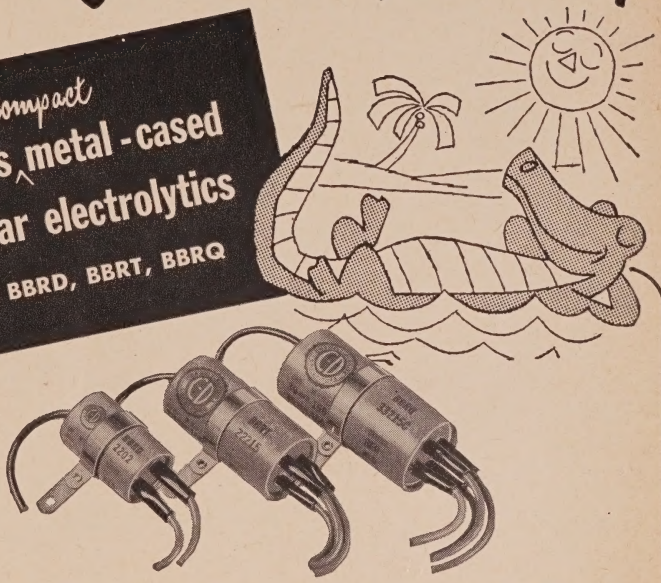

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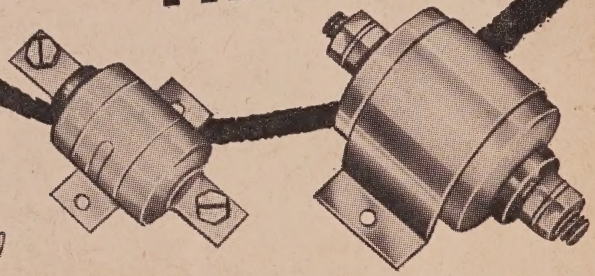

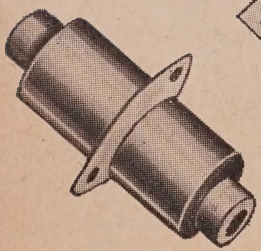

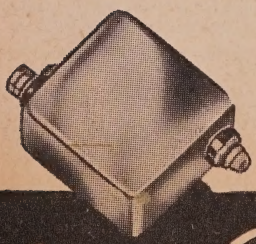

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